

Lorentz force in water: Evidence that hydronium cyclotron resonance enhances polymorphism.

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ABSTRACT

There is an ongoing question regarding the structure forming capabilities of water at ambient temperatures. To probe for different structures, we studied effects in pure water following magnetic field exposures corresponding to the ion cyclotron resonance of H_3O^+ . Included were measurements of conductivity and pH. We find that under ICR stimulation water undergoes a transition to a form that is hydroxonium-like, with the subsequent emission of a transient 48.5 Hz magnetic signal, *in the absence of any other measurable field. Our* results indicate that hydronium resonance stimulation alters the structure of water, enhancing the concentration of EZ-water. These results are not only consistent with Del Giudice's model of electromagnetically coherent domains, but they can also be interpreted to show that these domains exist in quantized spin states.

INTRODUCTION

The last century has seen a number of milestones related to the understanding of water, many often ignored by the biochemistry community, who in the past regarded water simply as a solvent with only one phase, a simple combination of molecules held together by short-range forces.

It was the discoverer of X-rays, Wilhelm Rontgen (1), who in 1892 first suggested that liquid water is comprised of two distinct phases, one the usually imagined loose configuration of water molecules, and the other more tetrahedral and ice-like. A few years later in 1912 the dual quality of water was confirmed by Hardy (2), and Perutz (3) demonstrated in 1949 that there was a thin layer of ordered water surrounding the methemoglobin structure. This led Albert Szent-Gyorgy to hypothesize (4) the existence of a specially structured form of water that is located immediately next to all biological entities. This type of water, variously called vicinal, interfacial, and most recently, excluded-zone, or E-Z water, has been studied extensively by Pollack (5).

It has been observed (6) that thick water layers contiguous to biological surfaces remain undisturbed when the surrounding fluid is vigorously stirred. An older term for this is bound water, referred to as such because microcalorimetric measurements (7) reveal that its boiling point is in excess of 300 °C. Pollack and Clegg (6) subsequently elaborated on these bound unstirred layers and EZ-water where solutes were unable to penetrate, after Mollenhauer and Morre' (8) reported in 1978 its presence in eukaryotic cells. More recent studies making use of small angle x-ray diffraction, electron spin resonance and Raman spectroscopy (9,10), tend to confirm the polymorphic character of ambient water, categorized as containing a combination of low-density and high-density liquid forms (11).

Throughout this long history, there have also been persistent reports, mostly anecdotal, that water is sensitive to magnetic fields, in a manner completely different from the well-known diamagnetic response (12) that is observed in very large magnetic fields. Although most of these claims have proven difficult to establish with certainty, the one very practical observation that appears factual is that attaching magnets to cold water lines helps reduce boiler scale, an effect that may possibly be explained as triboelectric. In this report we describe yet another magnetic effect in water, one that shows that its response to weak, low-frequency fields also influences its heterogeneous structure.

THE HYDRONIUM ION AND WATER STRUCTURE

Hydronium (H_3O^+) is an interesting ion with which to study ion cyclotron resonance (ICR) effects in water, mainly because its motion is less subject to the criticism voiced over ICR effects involving other cations. Ordinarily one does not expect low-frequency ICR effects in liquids because of the high cross-section for collisions. However it is well-documented that the motion of hydronium is anomalous in this regard. Because of the Grotthus mechanism (13), whereby proton-hopping occurs, its effective viscosity in water is greatly reduced, possibly making it a more suitable candidate for ICR.

In addition there is an unresolved question of how H_3O^+ ions are positioned within the coherent domains postulated for water by Del Giudice (14). He explained ICR in terms of cations excluded from the interior of these domains, thereby enjoying a higher mobility under the Lorentz force. The question therefore arises whether hydronium ions are also moved to the domain surface along with other positive ions. In other words if ICR

observations are perhaps explained by the concept of coherent domains, one might expect structural changes in these domains due to the resonant stimulation and exclusion of H_3O^+ . But because hydronium is necessarily chemically intrinsic to our usual picture of water, it seems likely that such stimulation would result in a drastic reconfiguration of the water structure that makes up the domain. It is relevant to ask, therefore, whether altered water structure also implies changes in hydronium concentration. Clearly there is the possibility that stimulation of this specific ion might lead to information relating to the question of water structure.

EXPERIMENTAL METHODS AND RESULTS

There were two parts to this study on pure water (MILLI-Q PLUS, 18.2 MΩ·cm, maintained under N_2), both carried out within a specially designed 3 x 4 x 2.8 m shielded room (Fig. 1), with 40 layers of μ -metal (VAC GmbH AK 3B), an approximate 10 nT magnetic field inside, and a baseline reduction of 60 db from outside. All signals entering and leaving this shielded room were carried on fiber optics, and all instruments inside this room were battery powered. The water was contained in a 70 mm long cylindrical plastic container, 86 and 88 mm inner and outer diameters respectively. This arrangement allowed us to apply magnetic signals along the axis, and also to detect magnetic signals in this direction. A 12-volt battery-powered Bartington MAG 03 3-axis fluxgate magnetometer with 10 nT sensitivity provided 0-10 V analog values of the magnetic field, for each of the three components of the magnetic field. The only component of consequence was that measured along the cylindrical axis of our system. Two types of fields were applied and one was measured along this axis, all plotted as a function of frequency in Figs. 4-8. One type of field was that combination of static and oscillatory parallel fields corresponding to the ICR tuning condition for hydronium, in one case, 7.83 Hz, 9.70 μT , and in the other, 33.72 Hz, 42.0 μT . This ICR field was generated by a 30 cm diameter, 100 turn Helmholtz coil coaxial with the water sample. A second type of magnetic field (a decoherence field) was in one case a neodymium permanent magnet, in another a solenoid-generated 50 Hz magnetic field, and in yet another case a 35 Hz magnetic field. Finally, the third variety of field measured along the cylindrical axis was a 48.5 Hz field that apparently had its origin in the water sample.

Following exposure to the ICR signal the water sample was transferred to a 2200 turn solenoid serving as a detector. The results shown in Figs. 4-8 were derived from a fiber optic output signal acquired by a National Instruments E 6036 card with a program developed on a Labview platform, with a sample rate of 1000 points/s.

In the first set of runs the water sample was exposed to the ICR field for up to ten minutes, during which time a gradual decrease in pH was observed (Fig. 2) in approximately 80% of the trials. A CRISON GLP pH meter with 52-02 glass electrode was used to obtain real-time pH values, in a manner similar to the digital collection of data described for the magnetic field. To confirm that this was indeed an ICR response a sinusoidal magnetic field at 35.0 Hz was found to elicit no change in pH. Because of this clear change in pH it could be immediately inferred that some sort of chemical change in the water had resulted from this ICR application, and that indeed hydronium was sensitive to the Lorentz force.

Making use of a Keithley 6485 picoammeter located outside of the shielded room, we also measured the change in conductivity in the water sample (Fig.3) following the application of this ICR signal, discovering a marked increase with the initial application and a gradual fall-off in time.

In the second series of trials we attempted to probe the nature of this change. Samples of water which had already been exposed to the ICR condition were further exposed for several minutes to a variety of magnetic fields, including a 50 Hz parallel decoherence field ($\geq 1 \mu\text{T}$) generated by the solenoid, and the retained effects in the water was measured over the course of an hour. Most interesting was the fact that water exposed in this way exhibited a magnetic field with a very specific frequency of 48.5 Hz after the solenoid-generated decoherence field was removed. This is shown in the frequency spectra given in Fig.4 where the water was examined at three later times: immediately following the remote exposure, 30 minutes later, and 60 minutes later. This field was not detected (Fig. 5) when the water sample was not exposed to the 50 Hz remote field, and could barely be observed (Fig. 6) when 35 Hz was used instead of 50 Hz. Although this effect was sometimes found to last in excess of one hour, it was temperature sensitive, disappearing completely at 60 °C.

To check on whether this spontaneous magnetic field was specifically the result of ion cyclotron resonance stimulation, we separately tested another ICR field combination corresponding to the H_3O^+ charge-to-mass ratio. Fig. 7

shows the magnetic frequency spectrum following a ten minute application of 33.72 Hz (42 μ T), and Fig. 8 shows the comparable spectrum following application of the non-resonant combination of 14 Hz (42 μ T).

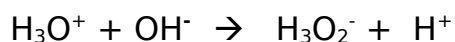
We make note of a similar response observed by Fesenko and Gluvstein (15) following irradiation of water by a much larger frequency, 36 GHz. However, instead of a magnetic oscillation they observed a voltage oscillation of 46.8 Hz that persisted for more than 60 minutes, and therefore **their** effect was interpreted as due to a capacitive discharge.

DISCUSSION

This work directly demonstrates that the Lorentz force acts on H_3O^+ ions, confirming implications raised by Mohri in his measurements (16) on the conductivity of water exposed to magnetic fields. Ion cyclotron resonance effects involving H_3O^+ are undoubtedly made possible by the fact that hydronium mobility in water is not limited by classical collision theory, but rather by the rapid exchange rates associated with proton-hopping.

Ordinarily at pH =7 the concentrations of hydronium and hydroxyl ions are the same, such that $[\text{H}_3\text{O}^+] = [\text{OH}^-]$. A lower pH means that $[\text{H}_3\text{O}^+]/[\text{OH}^-] > 1$, in effect requiring an increase in the number of protons. This is consistent with the increase in conductivity that was observed, a result that also confirms the earlier work of Mohri (16) and lends strength to his conclusion that he was likely observing an ICR effect.

The observed decrease in pH following application of magnetically tuned cyclotron resonance fields can be explained in more than one way. At first glance it might appear that this field causes a chemical change in the water, and very likely, a change in structure. The simplest chemical way of describing our results is to suggest that the following reaction occurs following application of the ICR magnetic field:



This is consistent with claims by Pollack (5) regarding evidence for an alternative water structure that he has labeled EZ-water, which supposedly carries excess negative charge. Thus one finds a new water structure consisting of hydroxonium, H_3O_2^- , with the additional creation of free protons. According to Pollack the hydroxonium or EZ-water component is highly contained, less diffusive, and restricted to its peripheral boundaries.

Therefore our interpretation of the reduced pH measurements we observed is that this reduction was more likely representative of the unattached low-energy protons, since the pH meter, located in the more liquid portion, could not adequately sense the acidity of the newly formed H_3O_2^- **less-diffusive** component.

Immediately prior to his sad passing, Del Giudice was pursuing the question of electric charge (17), studying the reasons for the concentration of what he called “almost-free electrons” within the coherent domains that he postulated, domains that are presumably rich in hydroxonium. We can follow this line of reasoning, suggesting that the magnetic fields we observed are consistent with Del Giudice, if we add to his picture by merely assigning spin states to his domains.

One can consider the following model. Each coherent domain can be thought of a spinning negatively charged sphere, with the **overall** ensemble of domains having an arbitrary distribution of spin moments. The application of a magnetic field will tend to align these moments, such that when the field is removed, a net field remains that in time decays because of thermal motion. In a certain sense such a system is similar to the electron spin moieties arising in magnetic domains, only scaled up in size, and consisting of large numbers of molecules instead of say, unpaired 3d electrons in single atoms.

This allows us to explain the oscillatory nature of this field. We adopt the view that the domains are only found in one of two possible opposite spin states, and that in the absence of a polarizing field, these states will tend to oscillate between these two states. In one sense this follows the suggestion by Del Giudice (17) that there are long-range oscillatory electromagnetic signals associated with these domains, although it remains unclear how these characteristic frequencies are determined.

There is a second potential explanation for the magnetic field that was emitted by the ICR treated sample of water. One cannot dismiss the possibility that this was the result of a charge flow, that is, an electric current acting to generate a magnetic field according to the Biot-Savart law. One can link the free protons that are created in the production of hydroxonium, as described in the above equation, with this current. In this scenario one would again find H_3O_2^- molecules lining the container walls, but in the form of long tetrahedral helical chains along which proton conduction occurs. However, unlike the explanation based on coherent domains, the reason for the oscillatory behavior in this case remains obscure.

Probably the most difficult thing to explain concerns our observation that water is restructured by exposure to cyclotron resonance magnetic fields tuned to H_3O^+ . We note that Novikov and Fesenko reported (18) that magnetic stimulation at the ICR frequencies of polar amino acids is capable of hydrolyzing polypeptides, an indication that water bonds are compromised even in situations where H_3O_2^- may not be directly stimulated. However it was not clear from this earlier work whether the observed hydrolysis was the result of a structural change in the water. It is conceivable that the explanation of why ion cyclotron resonance magnetic fields are biologically effective is connected to Del Giudice's concept that there are electromagnetic eigenfrequencies exhibited by coherent domains in water. The application of external ICR fields may therefore serve to mimic or excite these eigenfrequencies.

CONCLUSIONS

This report provides evidence in support of claims that water at ambient temperatures is heterogeneously structured. We observe that transitions to the putative EZ-water structure are enabled by relatively short exposure to ion cyclotron resonance magnetic fields tuned to the charge to mass ratio of the hydronium ion. We conclude that the much lower viscosity associated with the Grotthuss mechanism makes it possible for Lorentz force effects to be observed for H_3O^+ . It can be additionally concluded that similar effects are likely to occur endogenously in biological systems, considering the isotropic distribution of hydrogen atoms in water. Hydrogen atom isotropy ensures an infinite number of planes in which circular proton hopping can happen, potentially permitting all geomagnetic components to resonantly couple to internally generated low frequency biological signals.

The formation of this new water structure is indirectly reflected by the observed changes in pH. However this measurement likely does not accurately represent the overall acidity, but is sensitive to merely that fraction of proton-rich water that remains diffusible following the structural change. The most likely water component that defines the newly created structure are molecular arrays of hydroxonium, H_3O_2^- , formed circuitally at the peripheral boundaries.

We also discovered that, following a very limited application of a 50 Hz magnetic field to water displaying this new structure, the water sample upon

removal of this field consistently emits an oscillatory magnetic field at 48.5 Hz, which decays over the course of tens of minutes. **To the best of our knowledge, the observation of an oscillatory magnetic field emitted by water, in the absence of any other field, is unique, and not been heretofore reported.** This spontaneous magnetic oscillation is probably best explained in terms of Del Giudice's coherent domains, with the additional assumption that these negatively-charged domains also exhibit quantized spin states. This effect can be thought of as a new stable structure resulting from the ICR application which becomes unstable when exposed to a different field. **Without knowing the precise details of the underlying processes we arbitrarily refer to such destabilizing magnetic fields as decoherence fields. In short we find that ICR magnetic fields create new structures in water that, when broken down by decoherence magnetic fields, give rise to oscillatory magnetic emissions.**

There may be considerable clinical significance in these results. This type of water structure has been linked to biological processes (4,5), particularly in terms of how its interfacial quality helps or protects biological function. It is conceivable that there is considerable wellness advantage in maintaining or replenishing this structure, which we now find is enhanced by the application of suitable electromagnetic fields. In this regard it seems reasonable that the clinical efficacy associated with ICR applications (19) may be due to their equivalence to the characteristic eigenfrequencies for water domains predicted by Del Giudice.

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FIGURES

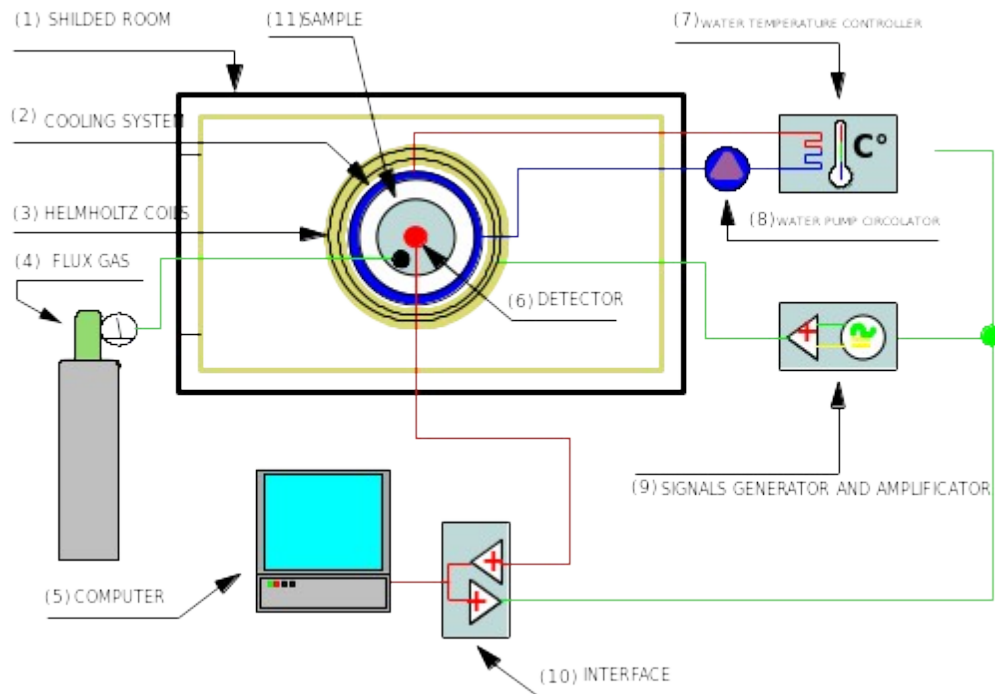


Fig. 1. Experimental set up. Water samples are contained within a Helmholtz coil in a specially constructed hypomagnetic room. All fields are applied and measured along the cylindrical axis.

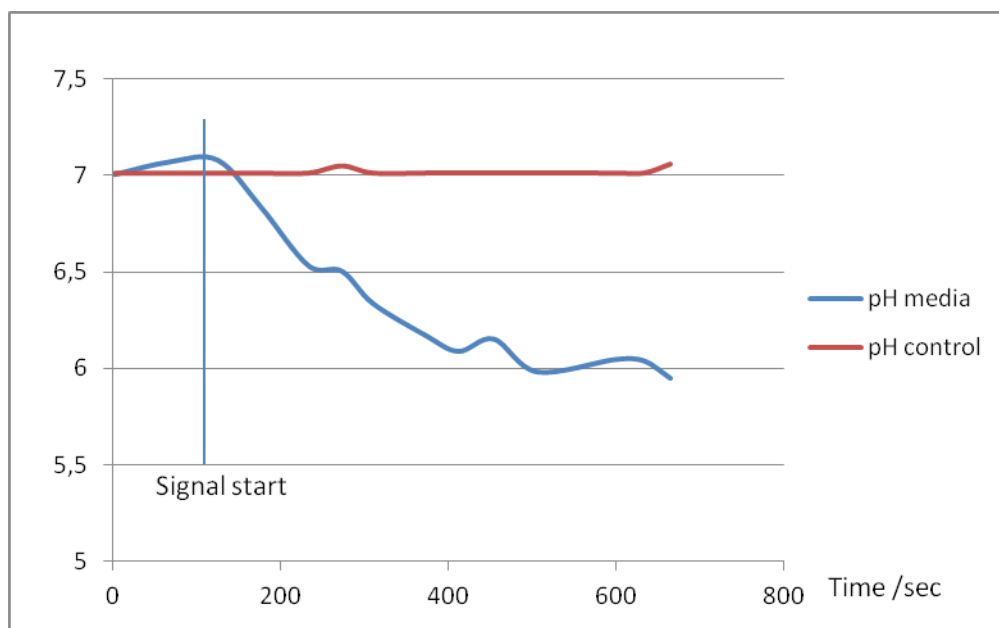


Fig. 2. Comparison of pH measurements as a function of time, unchanged in non-exposed water, but reduced in sample following exposure to ICR magnetic signal tuned to H_3O^+ . The latter change may not represent the actual overall level of acidity, but merely that fraction of more diffusible liquid external to the EZ-water component. Data shown here represents the average of ten runs.

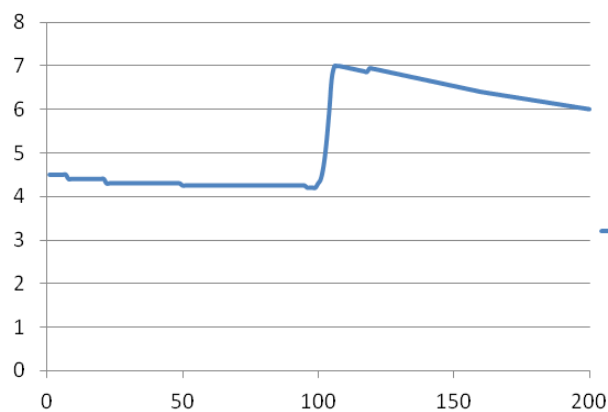


Fig. 3. Plot of conductivity in units of 10^{-5} S versus time in seconds along x-axis, showing effect of ICR tuning condition for H_3O^+ , applied at 100 seconds. Averaged over ten runs.

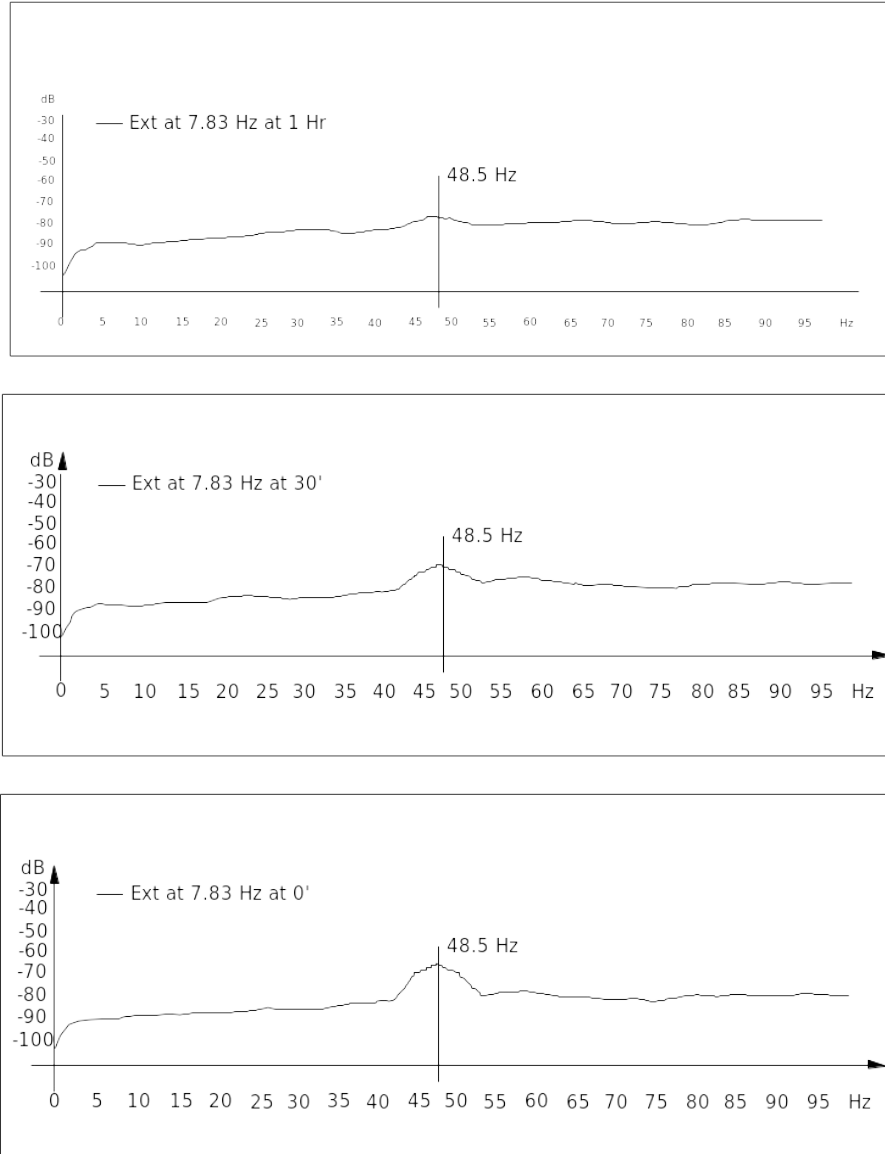


Fig. 4. Frequency spectrum showing spontaneous 48.5 Hz magnetic oscillation from water sample previously stimulated at ICR condition, measured at three times after the removal of a nearby 50 Hz **decoherence** signal: immediately after signal is removed, 30 minutes later, and one hour later. The vertical scale is an arbitrary measure of the magnetic field that was detected. **At no time during this hour-long observation was any other field generated within the hypomagnetic room.** This effect was also separately observed using a small permanent magnet instead of the 50 Hz field.

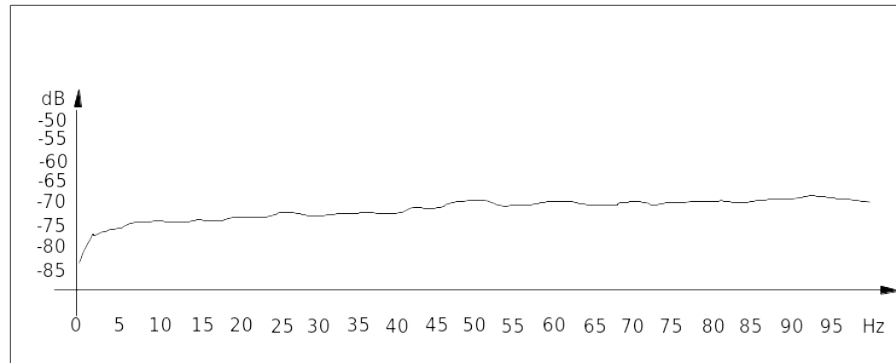


Fig. 5. Following ICR priming, the 48.5 Hz magnetic oscillation in water sample is barely visible in the absence of a magnetic decoherence signal.

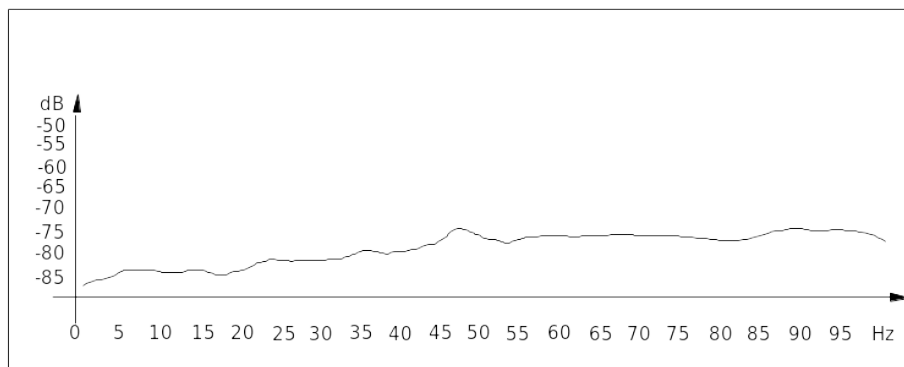


Fig. 6. The 48.5 Hz spontaneous magnetic signal is much weaker when 35 Hz is used as a decoherence signal instead of 50 Hz.

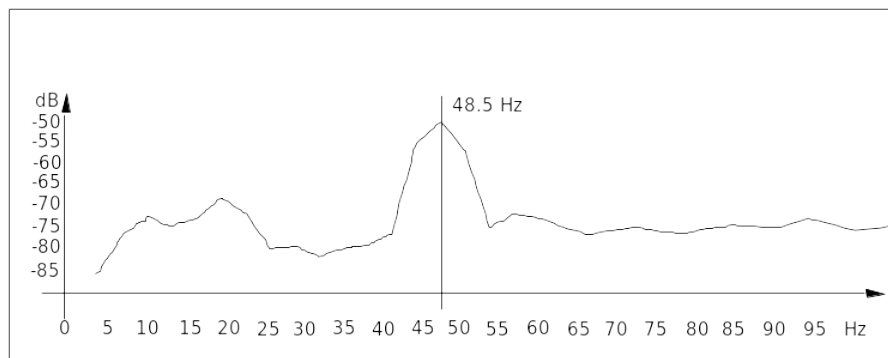


Fig. 7. Frequency spectrum showing 48.5 Hz output from water when sample is first exposed to an ICR condition for H_3O^+ , 33.7 Hz (42 μT). The rms level of the 33.7 Hz signal in this case was 7.7 μT .

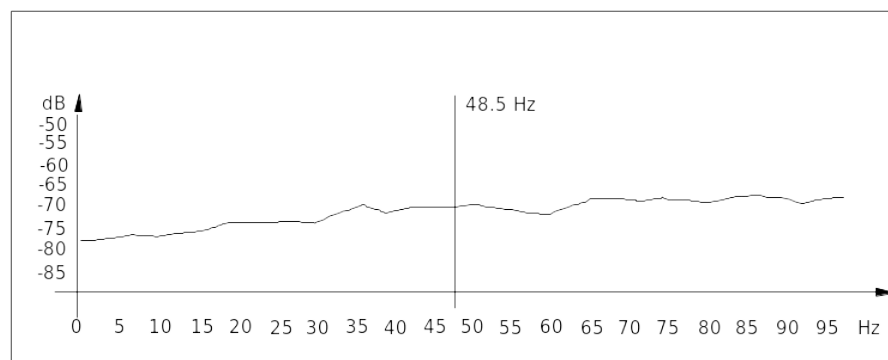


Fig. 8. Magnetic frequency spectrum obtained by changing the frequency used in Fig. 7 from 33.7 Hz to 14 Hz, thereby removing the ICR condition for hydronium.

